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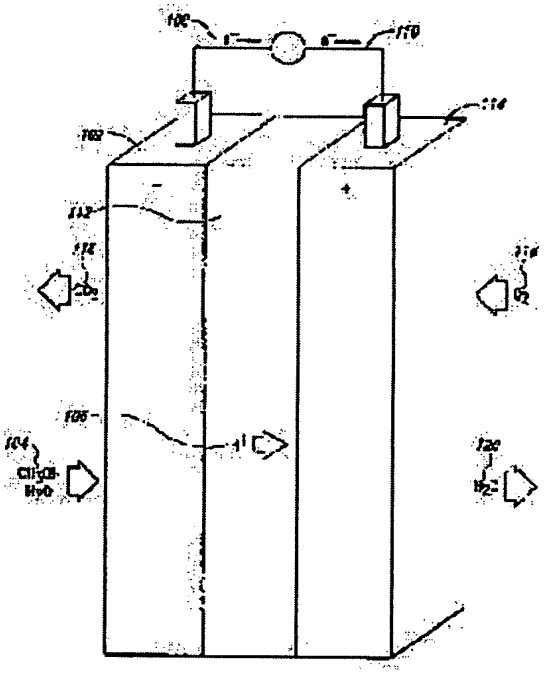
## (54) DYE-BASED FUEL INDICATOR SYSTEM FOR FUEL CELL

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a fuel cell capable of easily indicating the amount of a fuel remaining in the fuel cell and measuring the amount of the remaining fuel.
SOLUTION: One embodiment of the present invention provides a means for measuring the concentration of a hydrogen-rich fuel such as methanol within an anode reservoir of the fuel cell. The fuel concentration is measured by using a dye mixture responsive to fuel concentration. As the fuel is consumed, the fuel concentration decreases. The resulting color changes occur within the anode reservoir of the fuel cell, or within a dye chamber in fluid connection with the anode reservoir, and are made visible through a window. A color strip and fuel scale may be included to facilitate fuel concentration measurement based on the color of the fuel vessel. Additionally, a valve responding to dye color may control fuel supply.



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TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] The latest fuel cell can produce a current continuously over a long time, without needing a recharge. However, a fuel cell produces a charge, only when a fuel exists in an anode plate reservoir more than threshold concentration (threshold concentration). So, in order to guarantee the continuous action of a fuel cell, the display of the fuel quantity which remains in the fuel cell needs to be obtained easily. The fuel cell is not usually equipped with the convenient cost efficiency-equipment which can measure certainly the amount of the usable fuel which remains in the fuel cell. So, the designers of a fuel cell, manufacturers, and users came to accept the need for the convenient cost efficiency-equipment which can measure the fuel quantity which remains on the cell.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates to the color base fuel display system (dye-based fuel indicator system) which can be used with a fuel cell about a fuel cell.
[0002]
[Description of the Prior Art] A fuel cell produces electrical energy by making a fuel usually react to the bottom of existence of a catalyst with an oxidizer. Typically, a fuel cell consists of, a fuel electrode separated with the ionic conduction electrolytic solution, i.e., an anode plate, and a reduction electrode, i.e., cathode. an external circuit -- a conductor connects the electrode to an electrical circuit, i.e., a load. a conductor -- in inside, a current flows by electronic flow. In the electrolytic solution, a current flows by the flow of ion.
[0003] A fuel with many (hydrogen Rich) hydrogen contents of the numbers of arbitration, such as a methanol, ethanol, a butanol, and a propane, can be used as fuel sources. Drawing 1 is drawing of a methanol fuel cell. The reservoir which includes an anode plate or the anode plate reservoir 102 contains the methanol-water solution 104. Generally, a methanol fuel cell is in a charge condition, when the percent of the methanol in a methanol-water solution is comparatively large. The percent of the methanol in a methanol-water solution decreases, and the fuel cell is used up as a methanol oxidizes with a fuel cell and the electrical and electric equipment is generated.
[0004] In existence of a catalyst, the methanol contained in the methanol-water solution oxidizes and usually produces a hydrogen ion 106, an electron 108, and a carbon dioxide 116. This oxidation reaction occurs inside [ anode plate reservoir 102 ] a fuel cell. A bottom type shows a primary anodic oxidation reaction.
[0005]
CH3OH+H2O -> CO2+6H++6e-[0006] The reason which is the electric conductor which is not comparatively enough as for the electrolytic solution, and an electron 108 should care about flowing out of an anode plate via an external circuit 110. To coincidence, a hydrogen ion 106 lets the electrolytic solution or the film 112 pass, and goes to cathode 114 at it. Usually, there are Nafion112 (trademark), Nafion117 (trademark), and a poly benzoimidazole in the film used.
[0007] In the cathode 114 of a fuel cell, it is returned by the hydrogen ion 106 and the entering electron 108 from an external circuit 110 which move through the electrolytic solution 112, and water 120 is produced. A bottom type shows a primary cathodic-reduction reaction.
[0008]
3/2O2+6H++6e- -> 3H2O [0009] The electrode reaction according to individual described above as a primary anode plate and a primary cathode reaction turns into a comprehensive methanol fuel cell reaction shown below.
[0010]
2CH3OH+3O2 -> 2CO2+4H2O+ electrical and electric equipment [0011] A supplementary small chemical reaction may also occur and, generally heat energy is generated.

[0012]
[Problem(s) to be Solved by the Invention] The latest fuel cell can produce a current continuously over a long time, without needing a recharge. However, a fuel cell produces a charge, only when a fuel exists in an anode plate reservoir more than threshold concentration (threshold concentration). So, in order to guarantee the continuous action of a fuel cell, the display of the fuel quantity which remains in the fuel cell needs to be obtained easily. The fuel cell is not usually equipped with the convenient cost efficiency-equipment which can measure certainly the amount of the usable fuel which remains in the fuel cell. So, the designers of a fuel cell, manufacturers, and users came to accept the need for the convenient cost efficiency-equipment which can measure the fuel quantity which remains on the cell.
[0013]
[Means for Solving the Problem] In the one embodiment of this invention, the equipment for measuring the concentration of the methanol in the anode plate reservoir of a methanol mold fuel cell is offered. The concentration of a methanol is measured using the color mixture which induces the concentration of the methanol in a methanol-water solution. Since a methanol is consumed working [ the normal of a fuel cell ], the color mixture responds by changing a color. Therefore, various colors will arise into the liquid inside the liquid restoration chamber which is carrying out liquid communication with the liquid inside the anode plate container of a fuel cell, or the anode plate reservoir, i.e., a color chamber, as a methanol is consumed. By being among an anode plate reservoir or carrying out the observation comparison of the color of the liquid inside the color chamber which is carrying out liquid communication with the anode plate reservoir with the color of a corresponding color display bar color, a color display bar and a fuel scale may be united with a fuel cell so that the decision of methanol concentration may be made easy. Or the valve which induces the color of color mixture may be operated and fuel delivery may be controlled. In the alternative embodiment, the color mixture of various classes suitable for displaying the concentration of various hydrogen rich fuels is used.
[0014]
[Embodiment of the Invention] This invention offers a means to determine the concentration of the fuel inside a fuel cell. the inside of the methanol-water solution which set like 1 operative condition and was held in the anode plate reservoir in color mixture -- or it introduces into the color chamber which is carrying out liquid communication with the anode plate reservoir machine, and enables it to observe through a transparent window By normal actuation of a fuel cell, the concentration of the methanol in the methanol-water solution in an anode plate reservoir descends. Color mixture discolors as the concentration of a methanol decreases. Therefore, the color of a methanol-water solution is equivalent to the concentration of the methanol of the methanol-water solution in an anode plate container. In order to realize methanol density measurement based on the color of a methanol-water solution, a color comparison bar or a color strip, and a fuel scale may be included.
[0015] Drawing 2 A shows one embodiment of this invention equipped with the color type fuel drop which contacted the anode plate reservoir 202 directly. The anode plate reservoir 202 possesses the thin level long window 204 which can be seen from the outside of a fuel cell. It adheres to both on the outside of a fuel cell, and the color strip 206 and the fuel scale 208 are prolonged along with the level length of the window 204 bottom. The color strip 206 offers the convenient means for comparing the color of a liquid to the proofreading color which was displayed on the color strip 206 and united with the fuel scale 208. The color on the color strip 206 includes the range of the possible color generated with the color mixture in the methanol concentration in the range between a charge condition and an exhaustion condition. The color contained on the color strip 206 forms color inclination (color gradient) corresponding to the digital readout of the fuel concentration on the fuel scale 208. The fuel scale 208 is shown as a horizontal line which has the mark of a lot at equal intervals, and each mark expresses fuel concentration.
[0016] Drawing 2 A shows a liquid with a specific color observable through the window 204 in the anode plate reservoir 202. The color of the liquid can be compared with the color displayed by the color strip 206 under a window 204. The color of a liquid balances with the color on the color strip 206 corresponding to the methanol concentration to which 20% of the fuel supply which can be used

remains in drawing 2 A.
[0017] In the above-mentioned embodiment shown in drawing 2 A, a color is directly introduced into the anode plate reservoir 202. However, a certain kind of color mixture may be unable to interfere in actuation of a fuel cell, or may be unable to be used into a lot of fuel mixture too expensive and holding in the anode plate reservoir 202 interior. So, since [ which enables it to maintain the required concentration of a color molecule in the methanol-water solution of the small volume comparatively ] it dissociated from the anode plate reservoir 202, the color chamber 210 may be adopted.
[0018] Liquid restoration is carried out and the color chamber 210 must be carrying out liquid contact with the anode plate reservoir 202. This can be attained by various approaches depending on the physical characteristic of a fuel cell. Various designs will also be needed in order for a window 204 to look certain. Drawing 2 B shows the color chamber 210 separated from the anode plate reservoir 202 by semipermeable membrane 212. This film has the work which isolates the color molecule of the color chamber 210 interior, diffusing a methanol and water between the color chamber 210 and the anode plate reservoir 202. Notice the methanol-water solution in drawing 2 B about it being a methanol about 50%.
[0019] Drawing 2 C shows the alternative example into which the color chamber 210 is separated from the anode plate reservoir 202 by the fuel channel 214. Although the fuel channel 214 may have various die length and forms, it must have such the sufficiently large cross section that the balance of the methanol concentration in the color chamber 210 and the methanol concentration in the anode plate reservoir 202 can be expected within the suitable time amount limit. Drawing 2 C shows the semipermeable membrane 212 of arbitration which was explained in drawing 2 B again. Note that the anode plate reservoir 202 in drawing 2 C is in an exhaustion condition.
[0020] Drawing 3 A and drawing 3 B explain an example of the color molecule which induces the change condition in the environment of a color molecule, and is discolored. A certain kind of compound absorbs incident light. The color of the absorbed light is related to change of the internal state from a low energy condition to a high energy condition in these compounds. As for the wavelength of the reflected light from the solution containing such a compound, non-absorbing wavelength becomes thick. Therefore, supposing a compound absorbs a red beam of light, a green light line will be reflected from the solution, and supposing a compound absorbs a blue glow line, an orange beam of light will be reflected from the solution. In a nonpolar solvent, the energy-level difference between the conditions shown in drawing 3 A and drawing 3 B is smaller than the energy-level difference in a polar solvent. this special color -- a polar solvent -- a blue glow line -- absorbing -- and -- a nonpolar solvent -- a red beam of light -- absorbing -- a polar solvent -- orange -- and green is presented in a nonpolar solvent.
[0021] Drawing 3 A and drawing 3 B are Reichardts. The two conditions over a Dye molecule of having differed are shown. Drawing 3 A shows the color molecule in the low energy containing both positive charge 302 and the negative charge 304, a polarity, and a zwitter-ion condition. Drawing 3 B shows the same color molecule in high energy and a nonpolar condition. rather than it can set the energy difference between the high energy conditions shown in the low energy condition shown in drawing 3 A, and drawing 3 B with the polar solvent to a nonpolar solvent -- large -- therefore, the color -- a polar solvent -- a green light line -- and the Orange colored ray is emitted in a nonpolar solvent.
[0022] In this example, a color induces change of the dielectric constant of that solution by changing a color. However, a color may respond also like other conditions like the concentration of a metal ion, or pH of a solution. In the above-mentioned embodiment of this invention, a color induces change of methanol concentration.
[0023] The color mixture used for a color base fuel drop may contain the color from which versatility differed again. At one embodiment of this invention, it is Acid. Yellow 1 or Naphthol Yellow S and Solvent Blue The color mixture containing 37 is adopted. Drawing 4 A is Acid. The structure expression of Yellow1 is shown. This color mixture produces the color inclination by remarkable color change with underwater 10% methanol. At an alternative example, it is Acid. Red 29 or Chromotrope It is Sovent about 2R. Blue It uses combining 37 and the color inclination by remarkable color change which takes place between underwater 3% methanol and 1% methanol is produced. Drawing 4 B is Acid. Red The

structure expression of 29 is shown. per [ of 3.5mg of each of each color combination ] methanol-water-solution milliliter are used for both embodiments. In an above-mentioned embodiment, it dissolves in the methanol-water solution of a lot, each color mixture is changed into the condition of the methanol concentration between underwater 0.5% methanol and a pure methanol, and color inclination is generated. Much various color mixture which produces a useful color change in the methanol concentration which exists in a fuel cell is also noticed about a possible thing. Furthermore, various color mixture can be used also for the concentration display of the source of hydrogen rich liquid fuel of others in the fuel cell of an another side type.

[0024] Drawing 5 shows the embodiment of this invention about the color of the color which controls the fuel emission inside a cell. Drawing 5 shows the color base fuel drop which contacted the anode plate reservoir 502 directly. The anode plate reservoir 502 possesses a photodiode 504 and light emitting diode ("LED") 506. LED 506 floodlights light 508 to up to a photodiode 504 through the methanol-water solution in the anode plate reservoir 502. A photodiode 504 and LED Some approaches of operation can be used for 506. In the methanol content defined beforehand, by the color of a methanol-water solution, sufficient beam of light 508 from LED506 can be made to be able to reach a photodiode 504, and a photodiode 504 can be excited. A photodiode 504 generates the current which operates a device and makes a fuel emit into the anode plate container 502. Or it is LED by the color of a methanol-water solution at the methanol content defined beforehand. Sufficient beam of light 508 from 506 is made to reach a photodiode 504, and it stops exciting a photodiode 504. A photodiode 504 generates the current which operates a device and makes a fuel emit into the anode plate reservoir 502. Drawing 5 should care about omitting the window, the color strip, and the fuel scale in order to simplify an illustration. Moreover, drawing 5 shows the anode plate reservoir 502 as a thing of a configuration which is different rather than it can set to a previous illustration for simplification of an illustration. They are a photodiode 504 and LED to the color chamber which is carrying out liquid communication with the anode plate container in the alternative embodiment. 506 is adopted.

[0025] One embodiment of the fuel emission device shown in drawing 6 includes the fuel container 602 separated from the anode plate reservoir 604 by the door 606. A fuel container contains the almost pure methanol which does not add superfluous water. Two wires 608 and 610 prolonged from the photodiode (504 of drawing 5 ) touch the valve 612 which controls the aperture of a door 606. In the methanol content defined beforehand, by the color of a methanol-water solution, sufficient beam of light can be made to be able to reach a photodiode, and the photodiode can be excited. The electrical circuit in which send a signal to a valve 612 and a door 606 is made to be opened is completed. The methanol in the fuel container 602 can be made to emit into the anode plate reservoir 604 with gravity. Or it can also stop making sufficient beam of light reach a photodiode, and exciting the photodiode by the color of a methanol-water solution, in the methanol content defined beforehand.

[0026] Although this invention is described by the specific embodiment, it does not mean limiting this invention to this embodiment. Modification of the pneuma of this invention within the limits is clear to this contractor. For example, although two kinds of special color mixture is described, much various color mixture which can be used for sympathizing with concentration change of various fuels and making useful color inclination generate also exists. Color mixture may include a series of colors which make various color inclination of non-limits in various fuel concentration. The color mixture which produces a change remarkable in the color of the fuel in the various fuel concentration defined beforehand is employable. Decision of fuel concentration can be carried out based on the color which reacts with other adjustable environmental conditions like existence of a metal ion or pH, and produces color inclination. The fuel dump system of many various methods is also possible. It can operate by many various electric control valves or triggers which are used for the emitter receiver of a photodiode controlling delivery of the fuel to an anode plate container actively or passively. The emitter receiver of a photodiode may be arranged in the location of the arbitration in a fuel solution. Finally, about an aperture, a color strip, and a fuel scale, various different configurations, sizes, bearings, and locations can be used. For example, a color strip may be placed beside a perpendicular aperture, or may be twisted around the surroundings of a rectangular aperture. Furthermore, it is not necessary to necessarily put a

fuel scale on the bottom of a color strip. A fuel concentration mark may also incorporate a fuel scale as a part of actual color strip directly written on the color. Or a color chamber may produce the whole with a transparent ingredient without also attaching a color strip and fuel scale.
[0027] The above-mentioned description is the explanation purpose and used the characteristic idiom which brings about a perfect understanding of this invention. However, it is clear to this contractor not to need clear details, in order to carry out this invention. In other examples, the good and known part is shown as a diagram, in order to avoid the unnecessary derangement from fundamental invention. Therefore, the above-mentioned description about the specific embodiment of this invention is shown for the purpose of illustration and explanation. They do not tend to restrict the thing put into practice among the indicated exact form, either. From a viewpoint of the above-mentioned instruction, I hear that many corrections and modification are possible for a clear thing, and there is. The embodiment concerned is shown and described in order that this contractor may enable it to use for the best the various embodiments in which various corrections were made so that the particular application expected by this invention list may be turned to. The range of this invention shall be limited to the range list of the above-mentioned application for patent with those equivalents.
[0028] As mentioned above, although the example of this invention was explained in full detail, **** of each embodiment of this invention is shown hereafter.
(Embodiment 1) It is the fuel concentration drop characterized by being the fuel concentration drop which operates by oxidizing the fuel solution connected with a fuel cell, and said fuel concentration drop including the color mixture which induces fuel concentration within the volume of the fuel solution of the fixed volume, and a fuel solution.
(Embodiment 2) The volume of a fuel solution is a fuel concentration drop given in the preceding clause 1 characterized by holding in an anode plate reservoir (202) including a transparence window (204).
(Embodiment 3) It is a fuel concentration drop given in the preceding clause 1 which the volume of a fuel solution is held in a color chamber (210) with a transparence window (204), and said color chamber (210) carries out liquid contact with an anode plate reservoir (202), and is characterized by dissociating from the anode plate reservoir (202) with the film (212) which does not make color mixture penetrate although a fuel solution is made to penetrate.
(Embodiment 4) It is a fuel concentration drop given in the preceding clause 1 characterized by holding the volume of a fuel solution in a color chamber (210) with a transparence window (204), and for said color chamber (210) carrying out liquid contact with an anode plate reservoir (202), and dissociating from the anode plate reservoir (202) by the fuel channel (214).
(Embodiment 5) Color mixture is Solvent. Blue Fuel concentration drop given in the preceding clause 1 characterized by responding by containing 37 and becoming the methanol concentration in a methanol-water solution.
(Embodiment 6) A fuel concentration drop given in the preceding clause 1 characterized by controlling emission of a fuel solution by irradiating said photodiode by the transmitted light passing through the inside of the volume of a fuel solution including a photodiode and a luminescence device.
(Embodiment 7) Said fuel scale (206) is a fuel concentration drop given in the preceding clause 1 characterized by displaying the range of the possible color which answers various fuel concentration in the volume of a fuel solution, and is made with color mixture including a transparence window (204) and a fuel scale (206).
(An embodiment 8) How to prepare the step which determines the concentration of the fuel in a fuel solution by comparing the standard color which is the approach of measuring the concentration of the fuel solution in the fuel cell equipped with the anode plate reservoir (202), and was displayed on the color of the step which adds the combination of a color to the fuel solution held in the fuel container (202), and the fuel solution containing the added color mixture, and color inclination (206), and change.
(Embodiment 9) Color mixture is Solvent. Blue Approach given in the preceding clause 8 characterized by responding by containing 37 and becoming the methanol concentration in a methanol-water solution.
(Embodiment 10) An approach given in the preceding clause 8 characterized by a transparence window (204) measuring concentration of the fuel in a fuel solution by being stored in the liquid restoration

chamber which carried out liquid contact with the anode plate reservoir (202), and being able to observe from the outside of a fuel cell, and checking a fuel solution through said transparence window (204).

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[Translation done.]